

What is claimed is:

1 1. A high brightness illumination system, said system comprising:
 2 a plurality of modulatable light sources spatially separated in a prearranged
 3 pattern;
 4 drive means for exciting said light sources in a predetermined sequence to
 5 provide a plurality of light pulses that are separated in space and time; and
 6 scanning means for serially receiving and redirecting the outputs of said
 7 plurality of light pulses for travel in rapid succession along one or more collection
 8 paths to provide a collective output that is comparatively higher in brightness than
 9 would otherwise be possible with the light sources operating individually.

1 2. The system of claim 1 wherein each of said light sources illuminates over a
 2 predetermined solid angle, Ω_e , from a predetermined emitting area, A_e , and said
 3 collection paths collect illumination over a predetermined solid collection angle, Ω_c ,
 4 and collection area, A_c where the product $\Omega_e A_e$ is substantially equal to the product
 5 $\Omega_c A_c$.

3. The system of claim 1 wherein substantially all of the optical power emitted
 by each of said light sources is coupled into said collection path except for losses due
 to reflection and absorption.

4. The system of claim 1 wherein each of said light sources comprises a light
 emitting diode (LED).

5. The system of claim 4 further including a compound parabolic concentrator
 (CPC) for each of said plurality of sources for collecting radiation from a
 corresponding one of said plurality of sources and directing it in a given direction.

6. The system of claim 5 wherein each CPC is configured to operate by one
 of total internal reflection and reflective coatings.

7. The system of claim 4 wherein one or more of said LEDs emits radiation over predetermined spectral regions that is different from the spectral regions over the other LEDs emit radiation to control the color content of said collective output.

8. The system of claim 1 wherein one or more of said sources emits radiation over predetermined spectral regions that is different from the spectral regions over the other of said sources emit radiation to control the color content of said collective output.

9. The system of claim 1 wherein each of said light sources comprises a laser diode.

10. The system of claim 1 wherein said plurality of light sources is selected from the group consisting laser emitting diodes, xenon flash lamps, and laser diodes.

11. The system of claim 1 wherein said plurality of light sources comprises an array of sources each of which is arranged to emit radiation in a given direction and an array of compound parabolic concentrators (CPC), said array of sources and said array of CPCs being arranged with respect to one another so that each source emits radiation into a corresponding one of said CPCs and the outputs of said CPCs all are pointed in given directions.

12. The system of claim 11 wherein each individual CPC of said array of CPCs is configured to operate by one of total internal reflection and reflective coatings.

13. The system of claim 12 wherein said array of CPCs is fabricated as a single injection molded piece.

14. The system of claim 11 further including collimating optics for receiving said outputs from said CPCs and collimating them for downstream travel as a plurality of collimated beams.

1 15. The system of claim 14 wherein said scanning means comprises a
2 focusing lens, one of a re-imaging lens and compound parabolic concentrator, and a
3 scanning subsystem located intermediate said focusing lens and said re-imaging lens.
4 said focusing lens, said drive means, said scanning subsystem, and said re-imaging
5 lens being configured and arranged with respect to one another so that, when an
6 individual one of said sources is sequenced on by said drive means, said focusing
7 lens images its corresponding collimated beam onto said scanning subsystem, and
8 said re-imaging lens, in turn, re-images it onto the entrance of said collection path.

16. The system of claim 15 wherein said scanning subsystem comprises a scanning mirror having at least one tilt axis.

17. The system of claim 15 wherein each of said light sources illuminates over a predetermined solid angle, Ω_e , from a predetermined emitting area, A_e , and said collection paths collect illumination over a predetermined solid collection angle, Ω_c , and collection area, A_c where the product $\Omega_e A_e$ is substantially equal to the product $\Omega_c A_c$.

18. The system of claim 15 wherein substantially all of the optical power emitted by each of said light sources is coupled into said collection path except for losses due to reflection and absorption.

19. The system of claim 1 wherein said system has a folded optical path that comprises an initial leg and a final leg arranged at a predetermined angle with respect to said initial leg and wherein said light sources are arranged to emit radiation in a direction generally parallel to said initial leg and collect radiation along said final leg.

1 20. The system of claim 1 wherein said system has an optical axis wherein
2 said light sources are arranged radially around said optical axis to emit radiation along
3 paths in directions generally at an angle with respect to said optical axis, wherein said
4 collection path is arranged along said optical axis, and wherein said scanning means

5 is positioned along said optical axis to serially collect radiation from each of said light
6 sources and direct it generally along said optical axis to said collection path.

21. The system of claim 20 wherein said light sources are arranged around said optical axis to emit radiation generally perpendicular to said optical axis and said scanning means a rotating prism.

22. The system of claim 20 wherein said scanning means comprises an optical component selected from the group consisting of a mirror, prism, diffraction grating, acousto-optic modulator, wavelength division multiplexer, dichroic element, Fresnel mirror, and Pellicle mirror.

23. The system of claim 22 wherein said scanning means comprises an actuator selected from the group consisting of a stepper motor, DC servo motor, Voice coil, galvanometer, and micro-electromechanical device (MEMS).

24. The system of claim 1 wherein the brightness of said collective output is at least a factor of two brighter than the brightness of said individual sources operating continuously.

25. The system of claim 1 wherein the brightness of said collective output is at least an order of magnitude brighter than the brightness of said individual sources operating continuously.

26. The system of claim 1 wherein the brightness of said collective output is approximately a factor of twenty brighter than the brightness of said individual sources operating continuously.

27. The system of claim 24 wherein said plurality of sources comprise LEDs operating at duty cycles of less than 80%.

28. The system of claim 1 wherein said system has a folded optical path that comprises an initial leg and a final leg that is offset with respect to said initial leg and

parallel thereto and wherein said light sources are arranged to emit radiation in a direction generally parallel to said initial leg and collect radiation along said final leg.

1 29. The system of claim 28 wherein said scanning means includes a torroidal
2 mirror fixedly arranged around said final leg and a rotating prismatic element arranged
3 along and on said final leg, said torroidal mirror and said rotating prismatic element
4 being configured and arranged with respect to one another such that said rotating
5 prismatic element scans each of said plurality of light sources in turn as they are
6 sequenced on by said drive means to direct their respective outputs along said
7 collection path.

30. The system of claim 29 wherein each of said plurality of light sources itself comprises an subsystem array of sources and further including a triplet lens to converge the outputs from each subsystem array of sources onto said rotating array after which it further converges towards said final leg along which it is substantially focused.

1 31. A high brightness illumination system, said system comprising:
2 a plurality of modulatable light sources spatially separated in a prearranged
3 pattern wherein said plurality of light sources comprises an array of sources each of
4 which is arranged to emit radiation in a given direction and an array of compound
5 parabolic concentrators (CPC), said array of sources and said array of CPCs being
6 arranged with respect to one another so that each source emits radiation into a
7 corresponding one of said CPCs and the outputs of said CPCs all are pointed in given
8 directions;

9 collimating optics for receiving said outputs from said CPCs and collimating
10 them for downstream travel as a plurality of collimated beams;

11 drive means for exciting said light sources in a predetermined sequence to
12 provide a plurality of light pulses that are separated in space and time; and

13 scanning means for serially receiving and redirecting the outputs of said
14 plurality of light pulses for travel in rapid succession along one or more collection
15 paths to provide a collective output that is comparatively higher in brightness than
16 would otherwise be possible with the light sources operating individually, said
17 scanning means comprising a focusing lens, a re-imaging lens, and a scanning

18 subsystem located intermediate said focusing lens and said re-imaging lens. said
19 focusing lens, said drive means, said scanning subsystem, and said re-imaging lens
20 being configured and arranged with respect to one another so that, when an individual
21 one of said sources is sequenced on by said drive means, said focusing lens images
22 its corresponding collimated beam onto said scanning subsystem, and said re-
23 imaging lens, in turn, re-images it onto the entrance of said collection path.

32. The system of claim 31 wherein said scanning subsystem comprises a two-axis scanning mirror.

1 33. A method for providing high brightness source of illumination, said method
2 comprising the steps of:
3 mounting a plurality of modulatable light sources so that they are spatially
4 separated in a prearranged pattern;
5 exciting said light sources in a predetermined sequence to provide a plurality
6 of light pulses that are separated in space and time and higher in intensity than would
7 otherwise be produced by said sources operating continuously; and
8 scanning said outputs of said light sources to serially receive and redirect said
9 outputs for travel in rapid succession along one or more collection paths to provide a
10 collective output that is comparatively higher in brightness than would otherwise be
11 possible with the light sources operating individually.

34. The method of claim 33 wherein each of said light sources illuminates over a predetermined solid angle, Ω_e , from a predetermined emitting area, A_e , and said collection paths collect illumination over a predetermined solid collection angle, Ω_c , and collection area, A_c where the product $\Omega_e A_e$ is substantially equal to the product $\Omega_c A_c$.

35. The method of claim 33 wherein substantially all of the optical power emitted by each of said light sources is coupled into said collection path except for losses due to reflection and absorption.

36. The method of claim 33 wherein each of said light sources comprises a light emitting diode (LED).

37. The method of claim 36 further including a compound parabolic concentrator (CPC) for each of said plurality of sources for collecting radiation from a corresponding one of said plurality of sources and directing it in a given direction.

38. The method of claim 36 wherein each CPC is configured to operate by one of total internal reflection and reflective coatings.

39. The method of claim 36 wherein one or more of said LEDs emits radiation over predetermined spectral regions that is different from the spectral regions over the other LEDs emit radiation to control the color content of said collective output.

40. The method of claim 33 wherein one or more of said sources emits radiation over predetermined spectral regions that is different from the spectral regions over the other of said sources emit radiation to control the color content of said collective output.

41. The method of claim 33 wherein each of said light sources comprises a laser diode.

42. The method of claim 33 wherein said plurality of light sources is selected from the group consisting laser emitting diodes, xenon flash lamps, and laser diodes.

43. The method of claim 33 wherein the brightness of said collective output is at least a factor of two brighter than the brightness of said individual sources operating continuously.

44. The method of claim 33 wherein the brightness of said collective output is at least an order of magnitude brighter than the brightness of said individual sources operating continuously.

45. The method of claim 33 wherein the brightness of said collective output is approximately a factor of twenty brighter than the brightness of said individual sources operating continuously.

46. The method of claim 33 wherein said plurality of sources comprise LEDs operating at duty cycles of less than 80%.